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New karyotypes of Brazilian Akodont rodents with notes on taxonomy

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Abstract

Reported new G-banded karyotypes of *Akodon arviculoides* and *Bolomys lasiurus* (= *Zygodontomys lasiurus)* from northeastern Brazil with comments on the taxonomy of this last species. Several morphological and cytogenetical evidences indicate that the species *lasiurus* would not belong to the genus *Zygodontomys* but, should be included in the genus *Bolomys. Bolomys lasiurus* (= "*Zygodontomys" lasiurus)* showed karyotypes of 2n = 34 and 33, FN = 34 and this variation in diploid number

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is due to a centric fusion process involving pairs 6 and 7. The karyotype of 2n = 34 confirms the earlier diploid number already described for this species.

Akodon arviculoides, 2n = 16, FN = 26 and 25 presented a chromosomal polymorphism in pair 4 that shows a pericentric inversion in a heterozygous state. Karyotype of 2n = 16 represents one of the homozygous forms of the polymorphism of pair 1. The 2 other forms were described in specimens with 2n = 14 and 2n = 15 from southeastern Brazil, and also contribute with 2 new variants to the ten already reported, in this highly polymorphic species, by earlier authors.

Introduction

Among cricetid rodents a considerable number of related genera are grouped in the Neotropical tribus Akodontini (Vorontzov 1959) some of which have shown a high interspecific chromosome multiformity and remarkable intraspecific and intrapopulational sex chromosome and autosomal polymorphisms. Bianchi et al. (1971) reviewed the data on 13 species and 7 subspecies of *Akodon*, *Bolomys* and *Abrothrix* and pointed out some shared chromosomal characteristics between them: a. a high frequency of fusion-fission events involving the first pair of autosomes in *Akodon* sp. (Laguna Larga), *A. dolores*, *A. molinae* and "*A. illuteus*"; b. the constant presence of a pair of minute metacentric autosomes in all species studied (shared chromosomes); c. a high variability in the sexual chromosome pair of some species (*Akodon azarae*, *A. varius simulator* and *A. boliviensis*).

Further studies have been carried out with material from Brazil such as *Akodon arviculoides*, *Akodon* sp., *Akodon (Thaptomys) nigrita nigrita* and "*Zygodontomys*" *lasiurus* (Yonenaga 1972, 1975; Yonenaga et al. 1975; Yonenaga-Yassuda 1979). These last authors have also verified: a. complex rearrangements, including fusion-fission events, in the first pair of autosomes in *A. arviculoides* (2n = 14, 2n = 15). The product of such rearrangement – a very large metacentric chromosome – differs from those observed by Bianchi et al. (1971) mainly in respect to its size. In *A. arviculoides*, chromosome 1 represents almost 37 % of its female haploid genome. b. presence of the pair of shared chromosomes in the three species. c. variability in the sexual chromosome pair in *Akodon* sp. and "*Zygodontomys*" *lasiurus*.

The present paper describes further chromosomal polymorphism in *A. arviculoides* and *Bolomys lasiurus* (= "*Zygodontomys*" *lasiurus*). We are placing this last species in the genus *Bolomys* on the basis of morphological and cytogenetical data.

Taxonomic remarks on *Bolomys lasiurus*

Thomas (1902) was the first author to include the species *Mus lasiurus* Lund in the genus *Zygodontomys* and to consider this genus as a member of the Akodont group (Thomas 1916). According to Tate (1932) *lasiurus* is a species of *Zygodontomys* but he includes it in the Oryzomine group. Such a classification was maintained by Gyldenstolpe (1932). Tate (1932) still recognized five groups of species in the genus *Zygodontomys*: the first three ones inhabiting the Neotropics north of the Amazon river, and the last two groups (including *lasiurus*, *arviculoides*, *tapirapoanus*, *orobinus* and *brachyurus*) south of that river.

Ellerman (1941) regarded *lasiurus* as "probably a member of the genus *Akodon*". Cabrera (1961) pointed out that Brazilian forms of "*Zygodontomys*" are very closely related to the genus *Akodon* and Hershkovitz (1962) found it rather difficult to establish a clear distinction between these forms and *A. varius*, *A. arviculoides* and *A. obscurus*. Based on their cytogenetic data, Gardner and Patton (1976) believed that "*Zygodontomys*" *lasiurus* was sharply distinct karyotypically from the other *Zygodontomys* and that it would be better to consider this species as a member of the genus *Akodon*. Actually, there

is a great difference between the karyotypes of *lasiurus*, 2n = 34 (YONENAGA 1975) and 2n = 34 and 33 (present paper) when compared with those of *Z. microtinus*, 2n = 88 (GARDNER and PATTON 1976) and 2n = 84 (KIBLISKY et al. 1970) and *Z. brevicauda*, 2n = 84 (GARDNER and PATTON 1976).

The discrepancies over the genus *Zygodontomys* exist because authors have included in this genus species that actually belong to two different genera. One group of species which belongs to the "true" genus *Zygodontomys* (includes *Z. cherriei*, *Z. ventriosus*, *Z. seorsus*, *Z. sanctamartae*, *Z. brunneus*, *Z. punctulatus*, *Z. stellae*, *Z. thomasi*, *Z. microtinus* and *Z. brevicauda*. HERSHKOVITZ [1962] considers that all these forms should be better classified as subspecies of *Z. brevicauda*). Morphologically this genus is characterized by a skull with a long palate extending beyond the last molars, a long braincase, opisthodont incisives, paralofule absent, interparietal broad anteroposteriorly, phallus with prominent paratoid lobes, spineless outcurved urethral flap and a configuration of the dorsal crater rim similar to Oryzomines (HOOPER and MUSSER 1964). The other group that belongs to the genus *Bolomys* includes, according to REIG (1978), the following species: *B. obscurus* (including *benefactus*), *B. amoenus*, *B. lactens* (including *orbus*, *negrito* and *leucolimnaeus*), *B. lenguarum* (including *tapirapoanus*) and *B. lasiurus* (including *brachyurus*, *fuscinus* and *pixuna*). The species *arviculoides* also mentioned as a synonym of *B. lasiurus* actually does not belong to *Bolomys*. Morphologically *Bolomys* has a skull with a broad braincase, a short palate, orthodont incisors, paralofule present, interparietal narrow anteroposteriorly, midfrontal area with sharp strongly convergent edges. The configuration of bacular mounds, urethral processes and baculum approach conditions observed in *Akodon* (HOOPER and MUSSER 1964).

One of us (A. L.) compared the holotype and several specimens of *Bolomys amoenus* (type species of *Bolomys*) with specimens of *B. obscurus* and *B. lasiurus* kept at the British Museum (N. H.) and concluded that these three species are very closely related and that they probably belong to a distinct and well defined group at the generic level within the Akodontini. MASSOIA and FORNES (1967) proposed *Cabreramys* for this distinct group of species and REIG (1978), who studied all the Akodonts in British Museum (N. H.) suggested a similar classification but used the name *Bolomys* Thomas for this genus since it has priority over *Cabreramys*.

There seems to be, from a cytogenetical and morphological point of view, a close similarity between *B. lasiurus* and *B. obscurus* found in Argentina, Uruguay and southern Brazil. They all have the same diploid number (2n = 34), all the autosomal pairs being telocentric chromosomes with the exception of the smaller shared pair which is a metacentric. The X chromosomes are telocentrics in both taxa and the Y, a submetacentric in the first and a telocentric in the last species. A comparison of the G-banding patterns showed a great similarity between their karyotypes (KASAHARA, in litt.).

Material and methods

A total of 25 specimens of *Akodon arviculoides* and 70 of *Bolomys lasiurus* (= "*Z.*" *lasiurus*) were collected at different localities (Fig. 1 and tabs. 1 and 2) in the State of Pernambuco, Brazil, in a region more than 2000 km from the localities where karyotypes of animals of the same species have previously been described.

Studies were carried out in skins and skulls of the specimens that are kept in the Collection "Projeto de Mamíferos do Nordeste" (PMN) of the Departamento de Biologia Geral, UFPe, Recife, Brazil. Chromosome preparations were obtained by using the technique of FORD and HAMERTON (1956), slightly modified, in animals previously injected with colchicine 0.1 % solution (1 ml/0.1 kg for 2 hours). G-bands were produced by trypsin digestion and Giemsa staining (SEABRIGHT 1971).

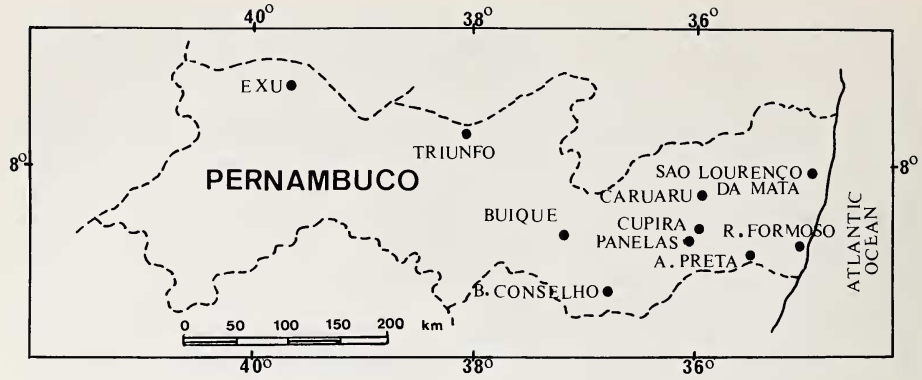

Fig. 1. Map of the State of Pernambuco, northeastern Brazil, showing the collecting localities of the specimens studied

Results

Akodon arviculoides

In all the 25 animals examined in this study the same chromosomal number of 2n = 16 was observed but not the same value of FN (Fig. 2 and 3). 23 specimens presented FN = 26, the complement being composed of 3 large submetacentric pairs (1, 2 and 3), two metacentric pairs of medium size (4 and 5), one acrocentric pair of medium size (6) and a pair of minute metacentrics (7). The heteromorphic XY pair was identified as consisting of 2 acrocentric chromosomes with different sizes. Two animals showed FN = 25. This difference in chromosome arm number is due to a heterozygous pericentric inversion, identified by G-banding, as present in pair 4.

Chromosome nomenclature used in this paper differs from that used by Yonenaga-Yassuda (1979) (see Fig. 2).

Bolomys lasiurus (= *"Zygodontomys" lasiurus*)

Two different chromosomal complements were found within the sample of 70 animals (Tab. 2). In 67 specimens a diploid number of 34 was established with FN = 34, the complement being composed of 15 pairs of acrocentrics grading in size and one pair of minute metacentrics, the shared chromosomes, similar to pair 7 of *Akodon arviculoides.*

Table 1

Diploid, fundamental number and collecting localities of *Akodon arviculoides* from Pernambuco, Brazil

2n	NF	Locality	Sex and specimen number
16	25	Bom Conselho	♂ PMN 165[1]
16	26	Rio Formoso	♀ PMN 319[1]–353[1]–354[1]–377[1]–410[1]–451[1]–452[1]–460[1]–461[1]
16	26	Rio Formoso	♂ PMN 262[1]–352[1]–361[1]–430–449[1]
16	25	São Lourenço	♀ PMN 381
16	26	São Lourenço	♀ PMN 419[1]
16	26	São Lourenço	♂ PMN 263[1]–295–301[1]–302[1]–413–420[1]–472[1]–473[1]

PMN = "Projeto Mamiferos do Nordeste".
[1] Animals with skull and skin preserved.

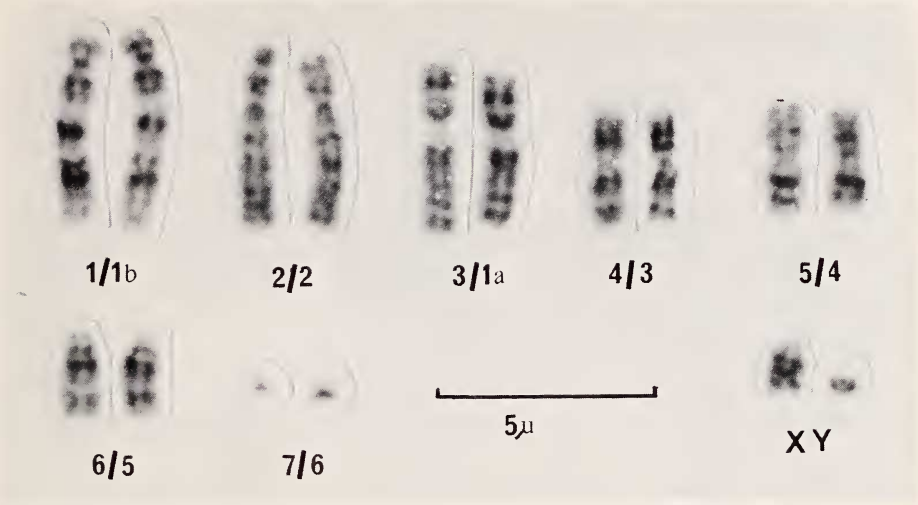

Fig. 2. G-banded karyotype of *Akodon arviculoides*, 2n = 16, FN = 26, ♂, specimen Nr. PMN 302. The first number under the chromosomes corresponds to our nomenclature, the second one to that of Yonenaga-Yassuda (1979)

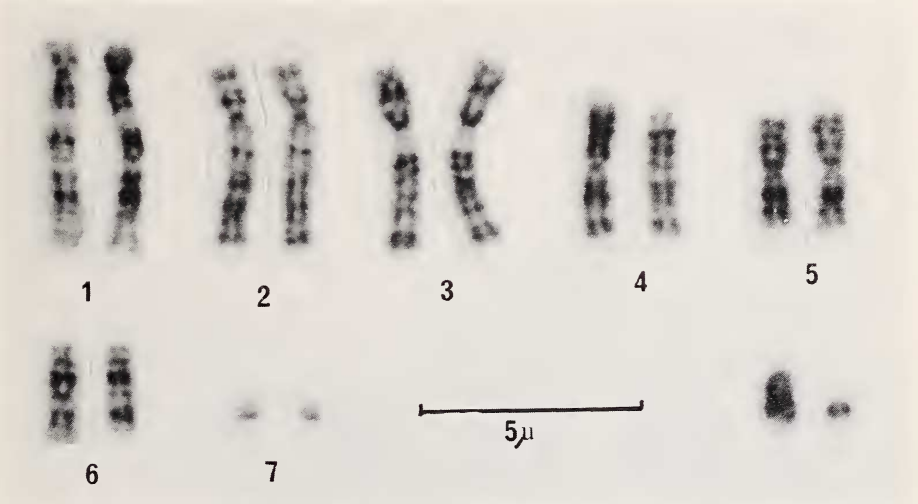

Fig. 3. G-banded karyotype of *Akodon arviculoides*, 2n = 16, FN = 25, ♂, specimen Nr. PMN 165

The X chromosome is a medium sized acrocentric and the Y a small submetacentric. Three animals with diploid number of 33, FN = 34, showed the existence of three chromosomes apparently without homologues: a large metacentric one and 2 acrocentrics which are similar in size to the arms of the metacentric chromosome. Through G-banding we could identify a Robertsonian centric fusion involving the chromosomes pairs 6 and 7 (Fig. 4 and 5).

Table 2

Diploid numbers and collecting localities of *Bolomys lasiurus* from Pernambuco, Brazil

2n	Locality	Sex and specimen number
34	Buique	♀ PMN 17–18–19–25–26–31–38–39–40
34	Bom Conselho	♀ PMN 114–117–221–222
34	Bom Conselho	♂ PMN 133[1]–115–116–223–471[1]
34	Panelas	♀ PMN 119–126–127–137–141
34	Panelas	♂ PMN 140
34	Cupira	♀ PMN 155–156–162–163
34	Cupira	♂ PMN 157–158–160–161
34	Agua Preta	♀ PMN 247
34	Rio Formoso	♀ PMN 388
34	Rio Formoso	♂ PMN 255[1]–271[1]–368[1]
34	Triunfo	♀ PMN 338–339–340
34	Triunfo	♂ PMN 323
34	Exu	♀ PMN 78[1]–79–86[1]–88[1]–92–370[1]–371[1]–384[1]–400[1]
34	Exu	♂ PMN 89–93[1]–94–100–403[1]
34	Caruaru	♀ PMN 184[1]–185[1]–190[1]–309[1]
33	Caruaru	♀ PMN 312[1]
34	Caruaru	♂ PMN 187[1]–191[1]–195[1]–310[1]–315–318–320–321
33	Caruaru	♂ PMN 186[1]–311

PMN = "Projeto Mamiferos do Nordeste".
[1] Animals with skull and skin preserved.

Discussion

The species *Akodon arviculoides* deserves interest owing to the occurrence of complex rearrangements in pair 1 and a high frequency of pericentric inversions in other autosomes. Our chromosomal data of specimens from northeastern Brazil show that the species has even more variation than described in the papers by Yonenaga (1972), Yonenaga et al. (1975) and Yonenaga-Yassuda (1979) where a high frequency of chromosomal polymorphism was reported for animals collected in southeastern Brazil. These authors have found pericentric inversions in pairs 2 and 3 of the complement 2n = 14, forming therefore

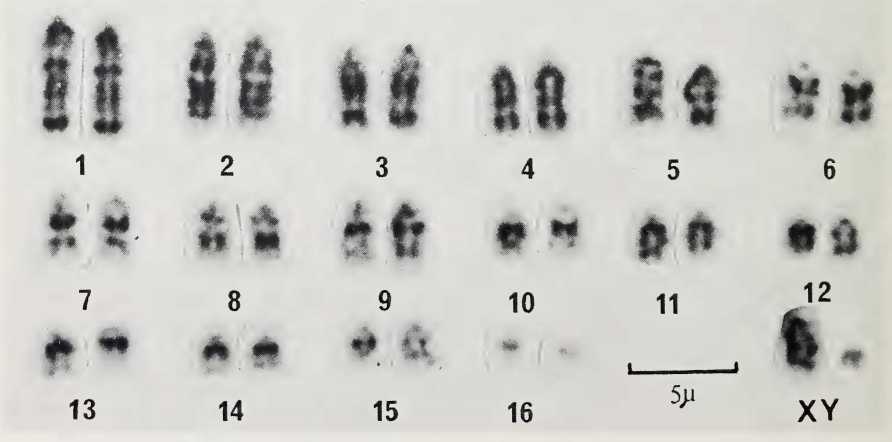

Fig. 4. G-banded karyotype of *Bolomys lasiurus*, 2n = 34, FN = 34, ♂, specimen Nr. PMN 133

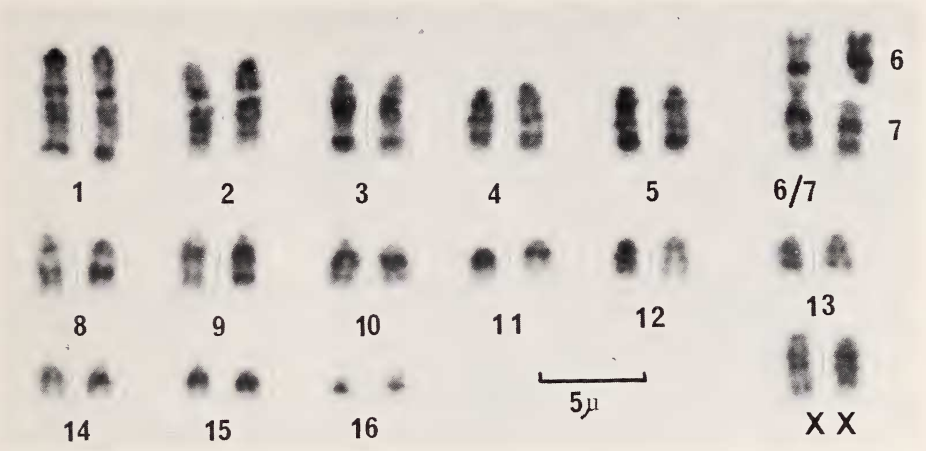

Fig. 5. G-banded karyotype of *Bolomys lasiurus* 2n = 33, FN = 34, ♀, with centric fusion between chromosomes 6 and 7. Specimen Nr. PMN 312

six different kinds of karyotypes. In our material with complement of 2n = 16, pair 4, which corresponds to pair 3 of the complement 2n = 14, has also a pericentric inversion in a heterozygous state in 2 of the 25 animals studied. Such rearrangement seems exactly identical in both of these complements. The degree of chromosomal variability in the samples from São Paulo and Rio de Janeiro is considerable higher than in our material. In addition to those six different karyotypes another four forms have been described (Yonenaga-Yassuda 1979) with 2n = 15, showing also inversions in pairs 2, 3 and 5. The diploid number of 15 is due to a complex rearrangement in pair 1, represented by a large metacentric and two submetacentric chromosomes. This polymorphism was basically explained by two alternative mechanisms: a. pericentric inversions in two submetacentrics, followed by centric fusion; b. chromosomal dissociation of the large metacentric followed by a pericentric inversion in one of the new chromosomes and activation of the latent centromere in the other one with a paracentric inversion. In our sample all animals have a diploid number of 16, having two pairs of submetacentrics (1 and 3) with the same banding patterns of those found in a single state in the karyotype 2n = 15 (1a and 1b). Thus it is clear that in the karyotypes with 2n = 16, 2n = 15 and 2n = 14 we find the three expected forms of the polymorphism of pair 1. Based on the generalized assumption that centric fusion is more prone to happen in rodents than fission events, one can speculate that 2n = 16 is the basic and ancestral karyotype.

Centric fusion was also observed in *B. lasiurus* with 2n = 33 and such an event reported here for the first time in this species, involves one chromosome of pairs 6 and 7. G-bands in the long and short arms of the metacentric chromosome are similar to G-bands of chromosomes 6 and 7 respectivelly. Similar rearrangements other than in pair 1 have been noticed in pairs 3, 4 and 5 in the akodontine *A. dolores* (Kiblisky et al. 1976). The karyotype of 2n = 34 found in the animals reported here, is similar to that observed in the specimens described by Yonenaga (1975) and G-banding patterns are identical to the ones studied by Kasahara (in litt.).

The animals with 33 chromosomes have been found in a limited area located at Serra dos Cavalos, Caruaru, Pernambuco, about 700 m above sea level. All the animals which were captured at different localities around this area showed 34 chromosomes (see fig. 1). Probably the centric fusion in animals with 2n = 33 originated in this area and has not yet spread to nearby populations.

The karyotype of *B. lasiurus* presents, as in other species of akodonts, the shared chromosome pair (16). An identical pair as well as heteromorphism in the X chromosome was described by YONENAGA (1975) for this species. Overall inspection of banding patterns published by BIANCHI et al. (1976) in *A. molinae*, *A. azarae* and *A. obscurus* suggests that G-banding homology in most chromosomes will probably be found when careful comparisons of the karyotypes of *B. lasiurus* with the latter species are made. Such homologies have been found by KASAHARA (in litt.) between at least 11 chromosome pairs of *B. lasiurus* and *B. obscurus*.

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Zusammenfassung

Neue Karyotypen von akodonten Rodentia aus Brasilien und Anmerkungen zur Taxonomie

Neue Karyotypen (G-Banden-Färbung) von *Akodon arviculoides* und *Bolomys lasiurus* (= *Zygodontomys lasiurus*) aus dem nordöstlichen Brasilien werden beschrieben. Die Taxonomie von *B. lasiurus* wird erörtert. Morphologische und zytogenetische Befunde zeigen, daß die Art *lasiurus* nicht zur Gattung *Zygodontomys* gehört, sondern zur Gattung *Bolomys* gestellt werden muß. *Bolomys lasiurus* hatte 2n = 34 oder 33 Chromosomen bei einer FN = 34. 34 Chromosomen sind die Norm und wurden schon früher für diese Art angegeben. Im Falle der Individuen mit 33 Chromosomen sind die Autosomen 6 und 7 einmal zentrisch fusioniert.

Akodon arviculoides hatte stets 2n = 16 Chromosomen, aber eine FN = 26 oder 25. Der Unterschied beruht auf einer perizentrischen Inversion von Autosom 4. Bereits früher sind aus Südost-Brasilien Tiere mit 2n = 14 und 15 Chromosomen beschrieben worden. Sie besitzen 2 bzw. 1 große, metazentrische Autosomen Nr. 1, die den submetazentrischen Autosomen Nr. 1 + 3 der Tiere mit 16 Chromosomen entsprechen.

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Winter diet of *Felis lynx* L. in SE Finland as compared with the nutrition of other northern lynxes

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Abstract

Studied the contents of 88 stomachs and 45 intestines of *Felis lynx* L. killed in winter in SE Finland, where no roe deer (*Capreolus capreolus* L.) were available. Four out of every five digestive tracts contained remains of hare, which accounted for 86 % of the weight of the stomach contents, the rest consisting of domestic and ranch animals, a red fox, small rodents, tetraonids and a redpoll. No significant dietary difference was found between the sexes.

Support was noted for the theory that female lynx are small because of their low total energy requirements and their ability to channel large amounts of excess energy into reproduction, and the males are large as a result of sexual selection.

A literature review shows that *F. lynx* hunts roe deer when available, and its large body size may thus be an adaptation to the use of roe deer as a food, while the reduced body size of *F. pardina* Oken, would be an adaptation to the use of rabbit-sized prey in warm climates. In northern North America, where there are no mammals of the size of the roe deer available, *F. canadensis* Kerr, similar in size to *F. pardina*, feeds mainly on snowshoe hares.

Introduction

At the very beginning of the Villafranchian, the Issoire lynx (*Felis issiodorensis* Croizet and Jobert) crossed along the Bering Bridge from North America into Eurasia and reached Europe, where it has been recorded at numerous sites dating from later in that era (Kurtén

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